Remarks

Claims 1-3, 5-11, 13-28 and 32-41 are pending in this application.

Claims 22-28, 32-35, 38, and 40-41 stand rejected under 35 U.S.C. 103(a) as being unpatentable over Szeliski et al. (US Patent Number 6,157,747, herein referred to as Szeliski) in view of Seago (US Patent Number 5,990,900). Claims 11, 13-21, 23, and 36-37 stand rejected under 35 U.S.C. 103(a) as being unpatentable over the combination of Szeliski and Seago, and in further view of Blank (US Patent Number 5,469,536). Claims 1-3, 5-6, 8-10 and 39 stand rejected under 35 U.S.C. 103(a) as being unpatentable over Szeliski in view of Luken (US Patent Number 5,923,334), and in further view of Seago. Claim 7 stands rejected under 35 U.S.C. 103(a) as being unpatentable over the combination of Szeliski, Luken, and Seago, and in further view of Blank.

Applicant wishes to thank Examiner Prendergast for the telephonic interview between the Examiner and Applicant's attorney, John Conway, on December 7, 2010. During the interview, the method taught by Seago '900 for modeling objects in 2D images was discussed. In particular, the applicability of Seago '900's teachings for preparing a 3D model of an object when no 2D image in a set of 2D perspective images contains the complete object was discussed. Attorney Conway maintained that Seago 900's disclosure does not teach steps for creating accurate 3D models from each 2D perspective image in a set of images when each 2D image leaves out a portion of the object. Examiner Prendergast pointed to passages from Seago '900 that she maintained indicated the applicability of Seago's method to this situation.

Attorney Conway stated the response would address this situation in more detail. This situation is addressed at page 26 and in appendix 1, below. Agreement was not reached during the interview.

Claim Rejections – 35 U.S.C § 103(a)

Claims 22-28, 32-35, 38, and 40-41 stand rejected under 35 U.S.C. 103(a) as being unpatentable over Szeliski et al. (US Patent Number 6,157,747, herein referred to as "Szeliski") in view of Seago (US Patent Number 5,990,900, herein referred to as "Seago").

The rejection of Claims 22-28, 32-35, 38, and 40-41 for obviousness over Szeliski in view of Seago must fail because neither Szeliski nor Seago teaches creating a geometric model of an object within an image panorama including identifying at least one boundary of the object where the object occupies a field of view in the panorama of greater than 180 degrees, as required by each of Claims 22-28, 32-35, 38, and 40-41. Details follow.

Claim 22 requires in pertinent part:

"(a)… receiving instructions from a user identifying a three-dimensional geometric surface within an image panorama, the image panorama containing an object having one or more textures, **the object occupying a field of view of more than 180 degrees in the panorama**;

…

(b) using the computer creating a geometric model of the image panorama based at least in part on the three-dimensional geometric surface and the directional vector, wherein creating a geometric model includes

identifying at least one boundary of the object and using the identified boundary to associate geometry information with the object, the geometry information comprising 3-D coordinates describing the position and orientation of the object boundary in a reference coordinate system;…(annotations added).

Likewise, independent Claims 32 and 38 include similar limitations to the cited limitations of Claim 22.

The subject office action admits that:

"Szeliski et al. does not specifically teach wherein creating a geometric model includes identifying at least one boundary of the object and using the identified boundary to associate geometry information with the object, the geometry information comprising 3-D coordinates describing the position and orientation of the object boundary in a reference coordinate system." (See, Office Action, page 21.)

Thus, if the combination of Szeliski and Seago teaches limitation (b) of Claim 22, Seago '900 must supply the teaching of modeling the object using an identified boundary of the object where the object occupies a field of view of more than 180 degrees in the panorama as required by limitation (a) of Claim 22. However, **Seago's method fails when the object to be modeled occupies a field of view greater than 180 degrees in the input image(s)**. Details follow:

The input to Seago's method is a 2-D perspective image or a group of 2-D images displaying the object to be modeled. (See, e.g., Seago, col. 11, lines 45-47). However:

(1) When the object to be modeled requires a field of view of more than 180 degrees, the entire object will not fit onto a single 2D perspective image. Each 2D perspective image in the set of images can show only a portion of the object; and

(2) Seago's method for modeling an object from multiple 2D perspective images **requires** that a separate 3D model be made of the object from each of the 2D perspective images. When each 2D image does not contain the entire object, Seago's method fails because the required 3D models of the object cannot be created. (See, Seago '900 col. 7, lines 29-33; fig. 6A, step 124; and col. 7 lines 50-53.)

Thus, Seago '900's method of 3D modeling will fail for any object that covers a field of view greater than 180 degrees in the input panorama and the combination of Seago '900 with Szeliski '747 will not satisfy the limitations of Claim 22 of the subject application.

Statements 1 and 2 concerning Seago's method are illustrated in figs. 1-12, which are shown below.

1. <u>Because the object requires a field of view of more than 180 degrees, the object will not fit on a single 2D perspective image. Each 2D image in the set of images will show only a portion of the object.</u>

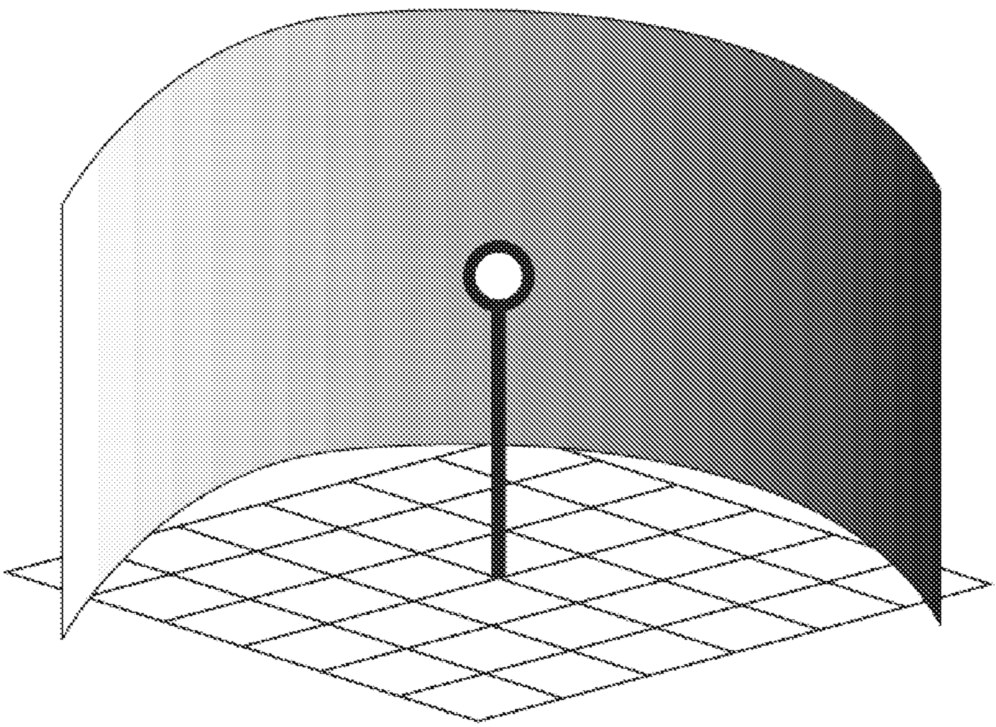


Fig. 1

The curved wall is an object that extends beyond 180 degrees in the input panoramic image. The lollipop represents the camera position; the wall object surrounds the camera position.

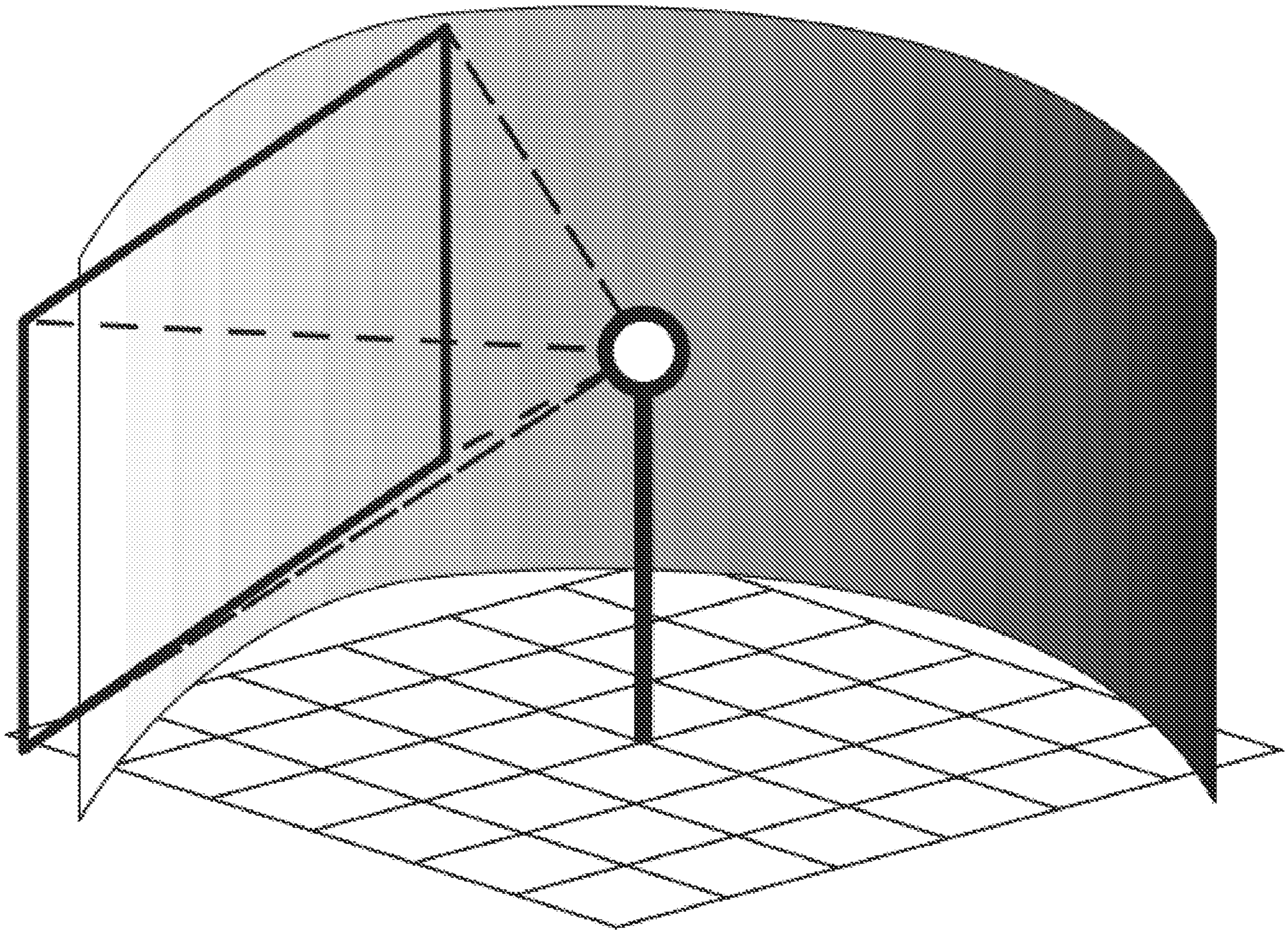


Fig. 2.

The camera acquires 2D perspective images. To create a mosaic similar to Szeliski, the user must take multiple overlapping photos to span the wall's extent, which is > 180 degrees.

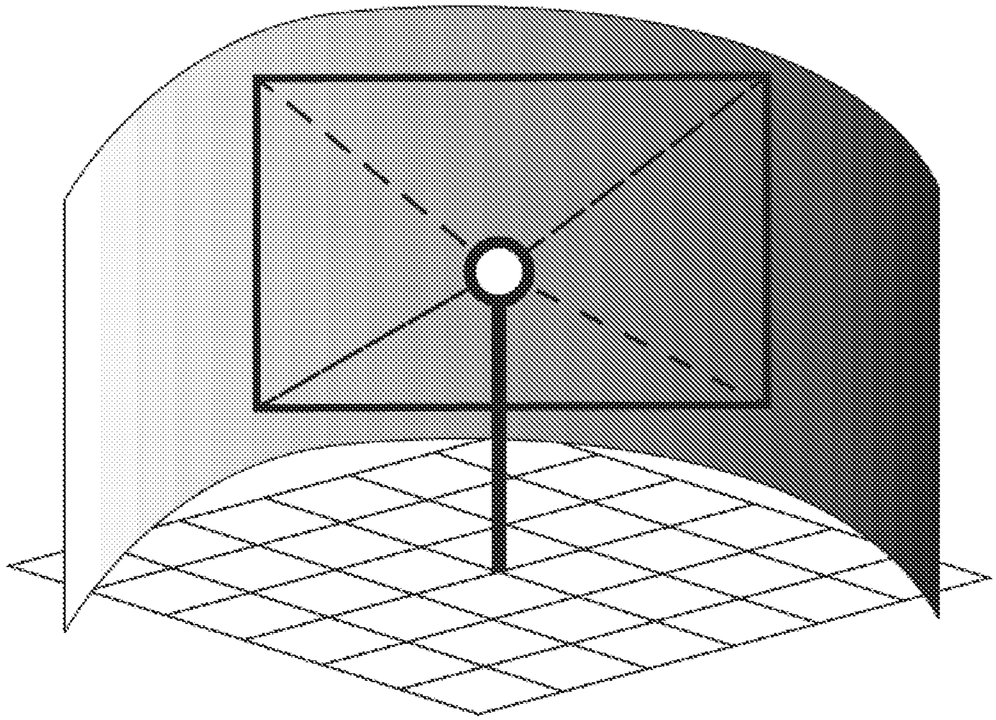


Fig. 3.

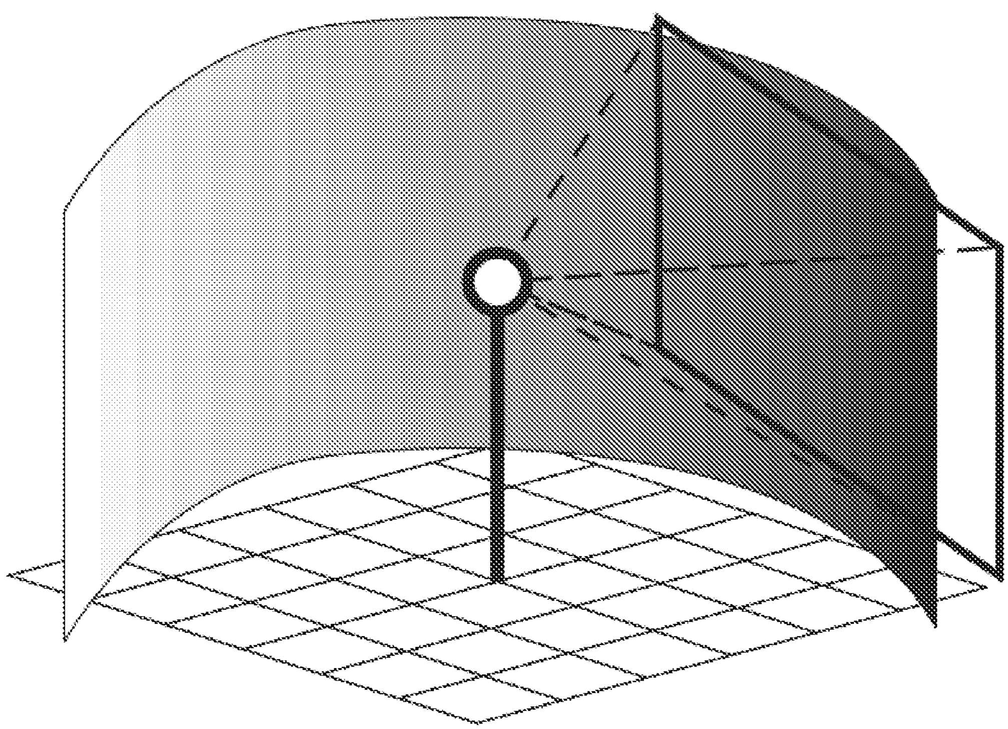


Fig. 4.

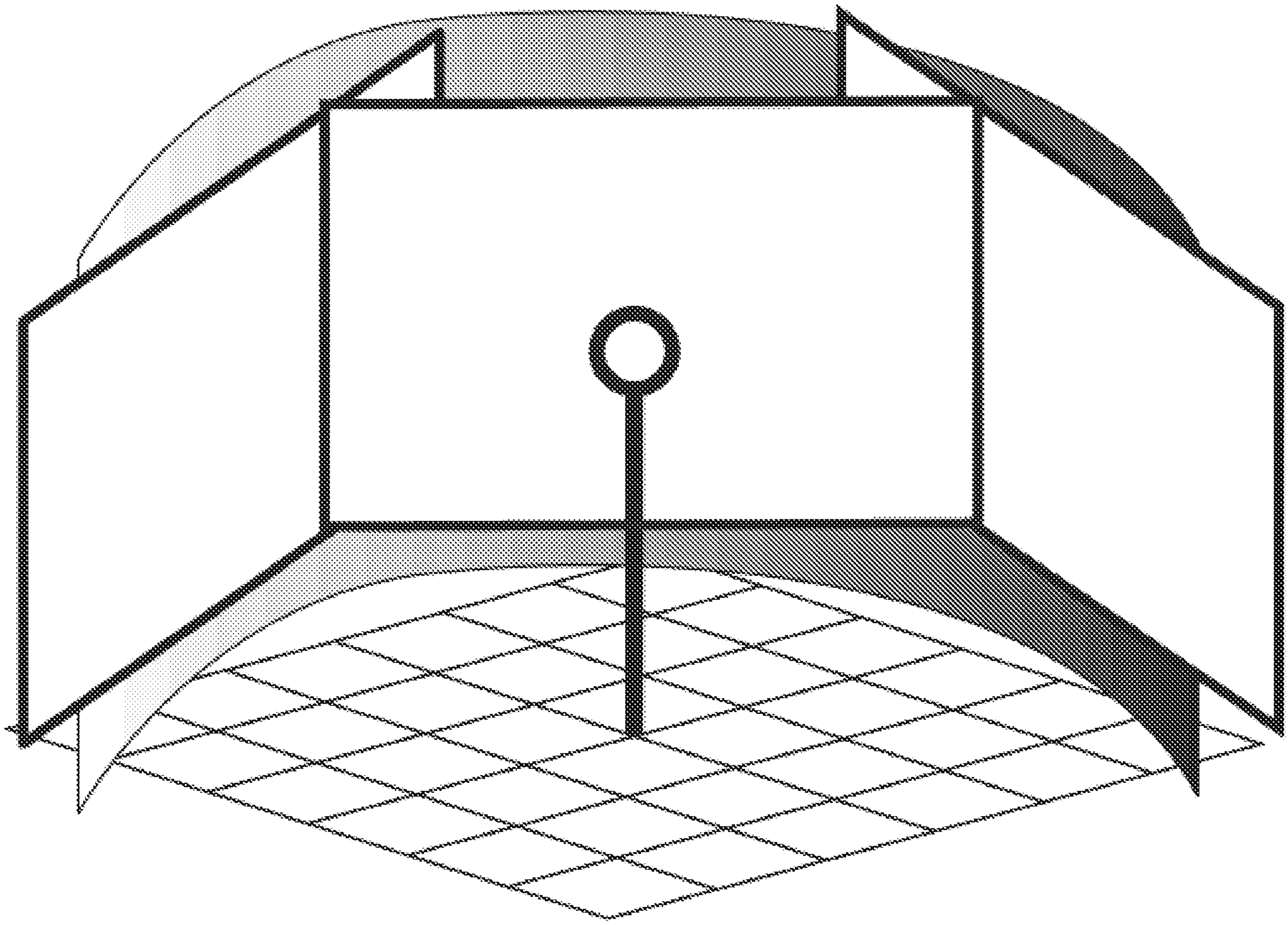


Fig. 5.

Without loss of generality, the mosaiced image to be used comprises three 2D images that have sufficient overlap to register the images.

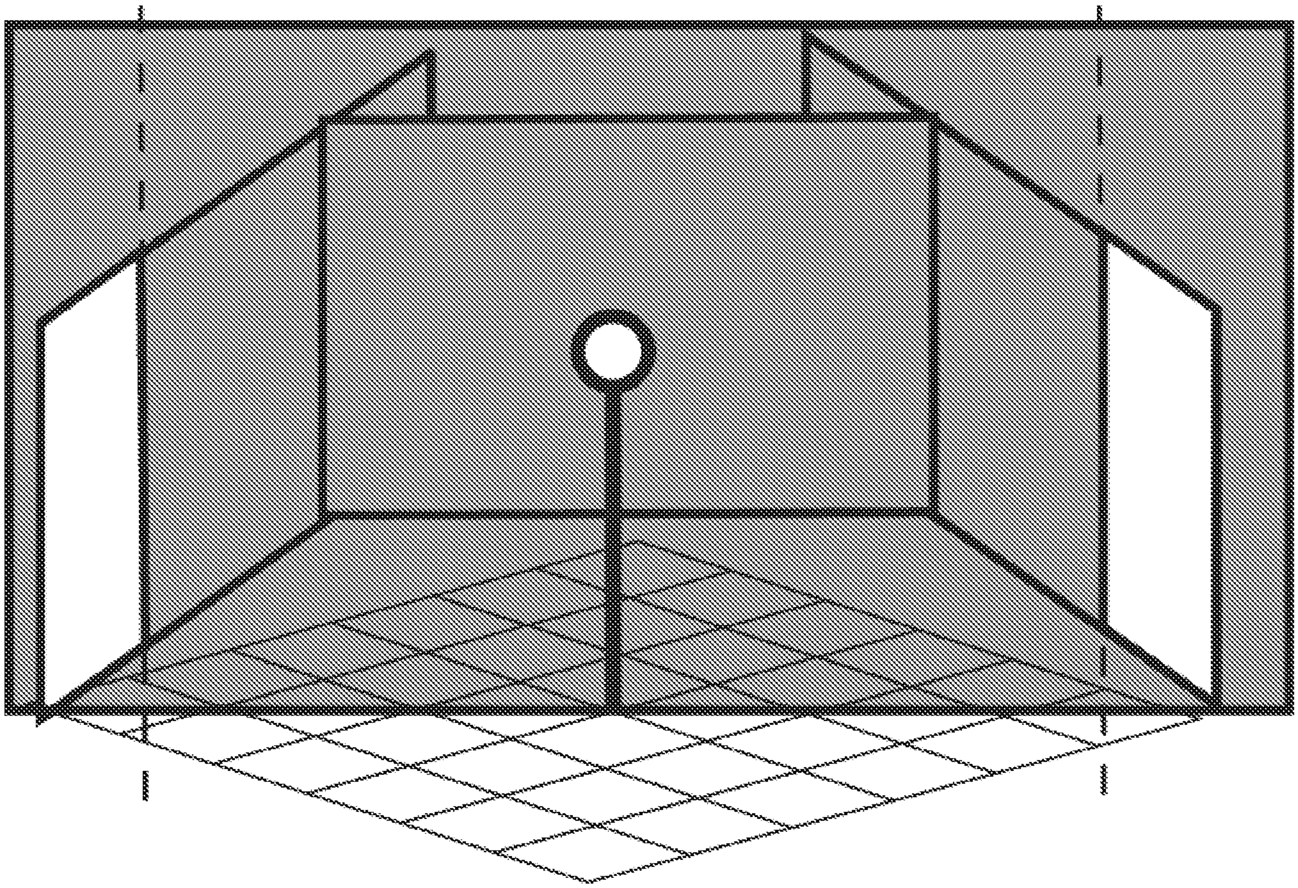


Fig. 6.

But the final mosaic created with the three initial images cannot be displayed as a single 2D perspective image that preserves the features that are used to register or model the scene and objects within the scene. As shown above, using Szeliski's method, the image pose cannot change without distorting the original images or cropping features not visible within the 180 degree limit for the 2D perspective image required as input for Seago's method. The white portions of the images of the wall object illustrate that at least a portion of the wall object will be left out of any single 2D perspective image. After all, the wall object spans a field of view with more than 180 degrees.

Warping and remapping a wall object that spans a field of view with more than 180 degrees so that it "fits" on a single 2D image would yield an image similar to fig. 7:

Fig. 7.

The warping needed to force objects with extents > 180 degrees onto a single 2D image destroys the perspective view of these objects. Such warping renders the single image useless for Seago's method, which demands perspective images of objects as inputs. (See, e.g., Seago fig. 2. In particular, steps 42, 44, 46, and 48 cannot be performed with a warped image.) To maintain perspective, such an object must be spread across multiple perspective images.

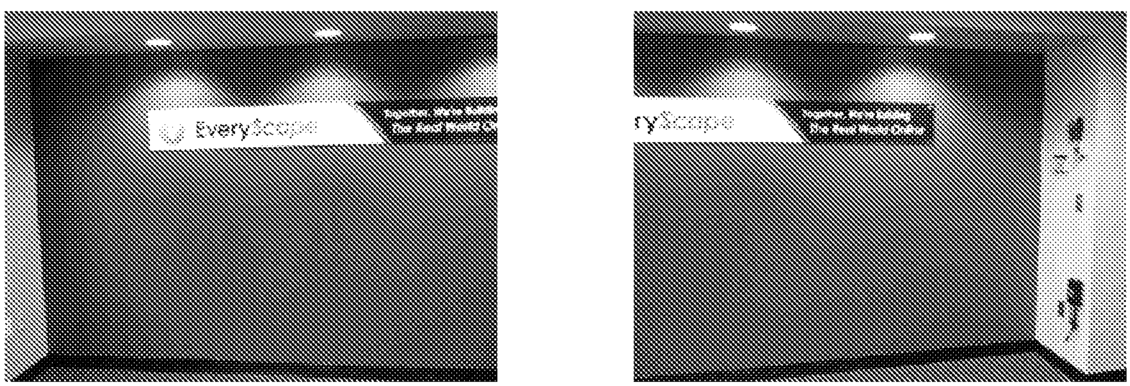
2. <u>Seago's method for modeling an object from multiple 2D perspective images **requires** that a 3D model be made of the object from each of</u>

<u>the multiple 2D perspective images. If each 2D image does not contain the entire object, Seago's method fails because the required 3D models of the object from each image cannot be created. (See, Seago '900 col. 7, lines 29-33; fig. 6A, step 124; and col. 7 lines 50-53.)</u>

Seago 900's method of modeling a 3D object from a 2D image is described at col. 4, line 34 through col. 6, line 35. Fig. 2 of Seago '900 is a flow chart that shows Seago's steps for creating the 3D model. Steps 42 and 44 in fig. 2 comprise:

> "The approximate orientation determination involves visualizing the selected object and determining the location of the selected object's three orthogonal sides or in other words the object's natural coordinate system. Using the perspective image, the user approximates the location of the vanishing points of the selected object within the image plane. The first step in the determination of vanishing point locations is at block 44, where lines are created that overlap parallel lines on the selected object or other objects within the digital image that appear to have the same orientation (i.e., have the same vanishing points and natural coordinate system) as that of the selected object based on the approximate orientation determination. Line creation can be performed automatically by image analysis software, which determines edges of objects and creates lines overlapping the determined edges. More preferably, the user uses line generating software to designate these lines. The lines overlapped on the selected object are lines that lie parallel to one another on the actual object represented by the image of the selected object. On the displayed two-dimensional perspective image, the overlapped lines do not appear to be parallel, but appear to converge at varying angles to the vanishing points. **The minimum number of lines required for each of the three vanishing points for this designation step is two.** Line designation is illustrated in FIG. 7 and described in more detail below. Following line designation, the system calculates vanishing point…" (Seago '900, col. 4, line 53 to col. 5, line 12.)

Clearly, if any of the object's three orthogonal sides cannot be located in each image, steps 42 and 44 cannot be performed. Using the simplest example of a wall that does not fit on a single 2D image, consider the process of geometrically modeling the wall, which is taken as two overlapping images, A and B. (It is easy to construct a more extreme example of how Seago's method must fail when the object will not fit entirely on a single 2D image -- such as a wall object that spans more than 180 degrees.)



A B

Fig. 8.

To model a plane, four points or edges need to be corresponded between images A and B. However, because image A contains only a portion of the wall, points 3 and 4 that describe the wall's rightward extent must be selected arbitrarily, as shown in figs. 9. and 10:

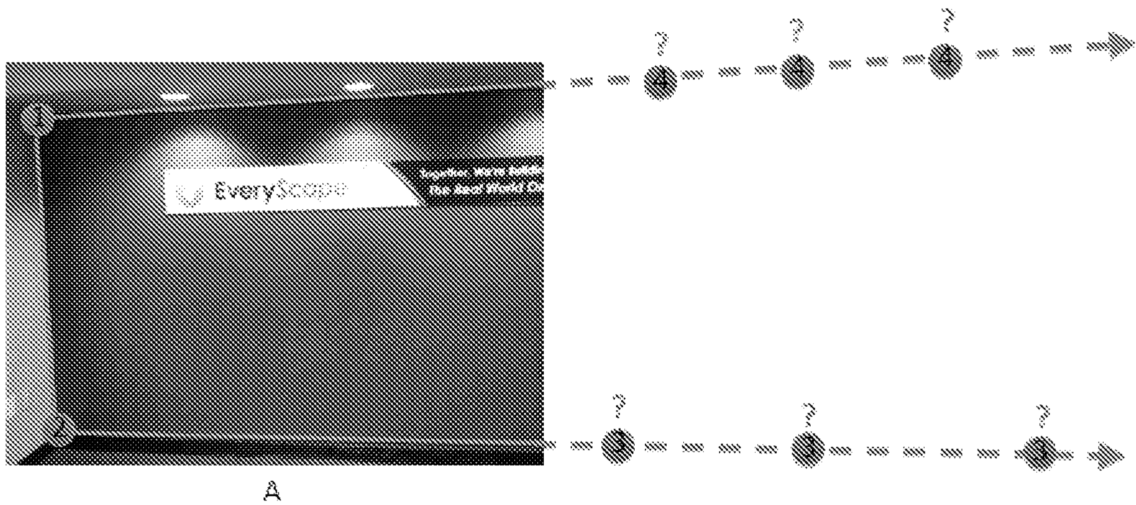


Fig. 9.

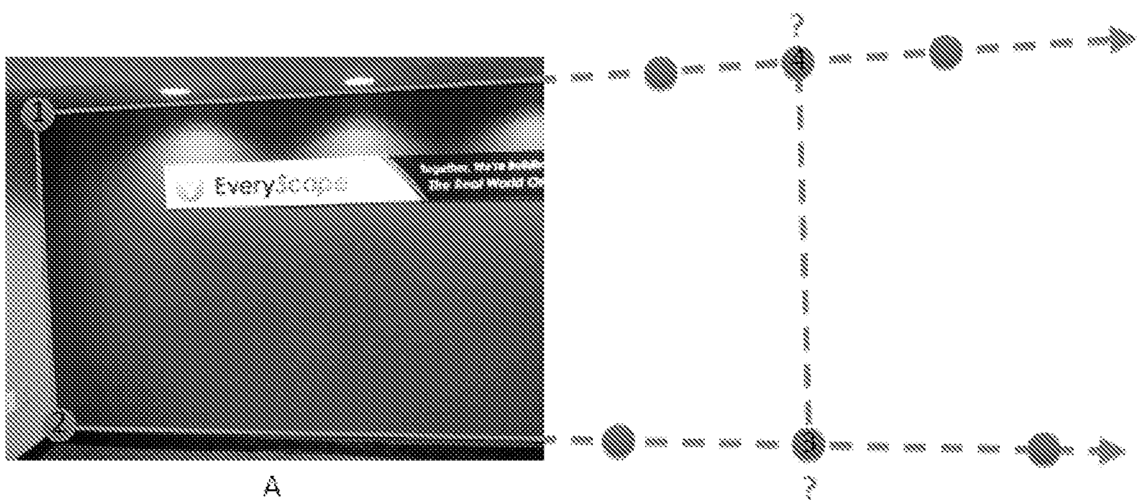


Fig. 10

Because no features are visible for vertices 3 and 4 for the wall object in image A, the slope and position of line 3-4 cannot be determined unambiguously. (The questions marks in fig. 10 denote this uncertainty.)

Thus, steps 42 and 44 in fig. 2 of Seago '900 **cannot** be performed accurately for image A for the rightmost orthogonal side of the wall object. Thus, Seago's method will fail to produce a 3D model of the wall from image A.

Likewise, in image B, vertices 3 and 4 are visible in the image and can be determined with certainty, but vertices 1 and 2 are arbitrary as shown in figs. 11 and 12:

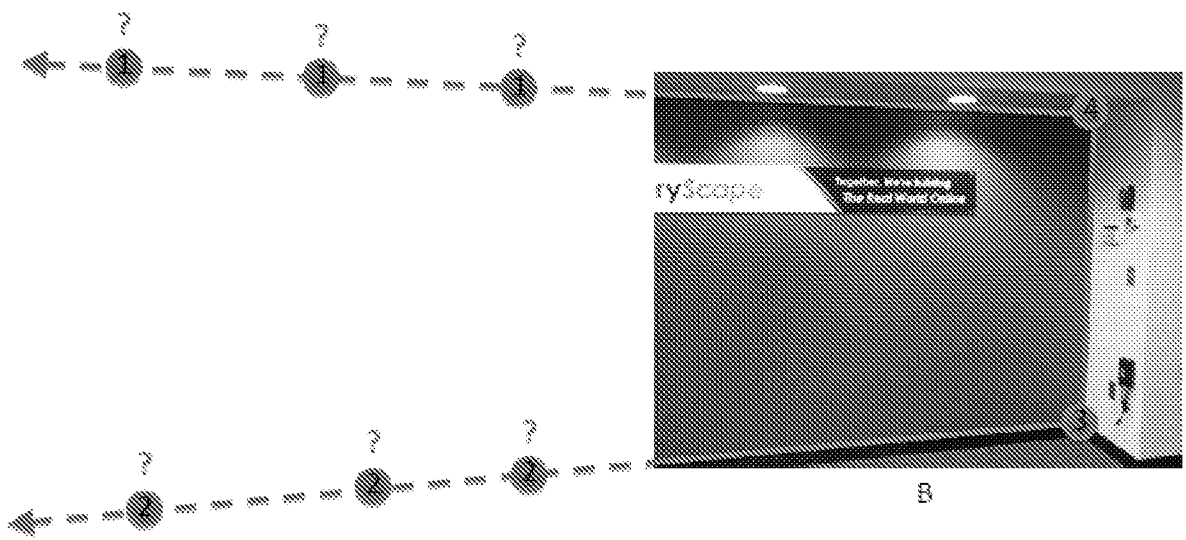


Fig. 11.

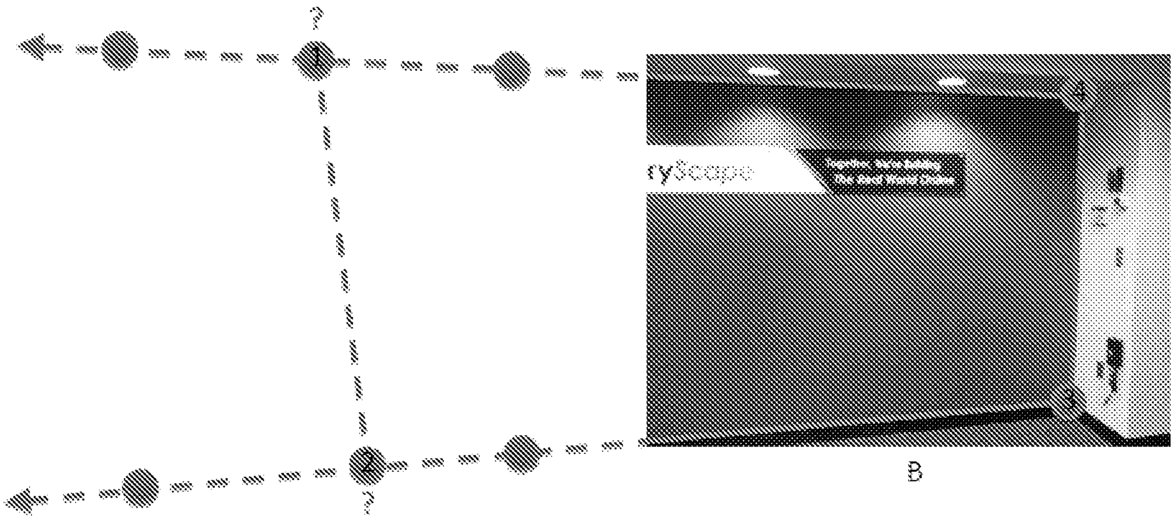


Fig. 12.

Because no features are visible for vertices 1 and 2 for the wall object in image B, the slope and position of line 1-2 cannot be determined unambiguously. (The questions marks in fig. 12 denote this uncertainty.) Steps 42 and 44 in fig. 2 of Seago '900 **cannot** be performed accurately for image B for the rightmost orthogonal side of the wall object. Thus, Seago's method will fail to produce a 3D model of the wall from image B.

Thus, Seago's method will fail because separate 3D models cannot be created from each of the multiple 2D perspective images needed to show an object with extent > 180 degrees.

Seago '900 only addresses generating a single three-dimensional object from two or more three-dimensional objects created from two-dimensional

images of a single object at col. 7, line 29 through col. 8, line 42; fig. 6A and 6B; and col. 11, lines 45-47. **Please refer to appendix 1, attached below, for a discussion showing that these portions of Seago '900 do not remedy the deficiency in creating an accurate 3D model from multiple incomplete 2D perspective image that was described above.**

To be sure, Szeliski '774's method can be used to produce a single 2D image that has four vertices visible to model in the case of the wall shown in figs. 8-12, since the wall's extent is not greater than 180 degrees. But for objects that require more than a 180 degree field of view, the necessary vertices (and edges/planes) cannot be projected onto a single 2D perspective image to satisfy Seago '900's method. (See figs. 1-7 and accompanying discussion above.) If a mosaic/panorama with an object extends beyond 180 degrees, the image needs to be warped/remapped to fit into a single 2D image. Warping or remapping features does not work for Seago's method because Seago's method relies on perspective, e.g., straight lines on objects are no longer straight, etc.

Because step "b" of Claims 22, 32 and 38, for objects that occupy a field of view greater than 180 degrees as required by step "a," is neither taught nor suggested by any combination of the teachings of Szeliski '774 and Seago '900, a prima facie case of obviousness is lacking. Claims 22, 32 and 38 are therefore deemed patentable. Claims 23-28, 33-35 and 40-41 depend from Claims 22, 32, and 38, respectively and add further limitations. Each of these

claims is deemed nonobvious over Szeliski in view of Seago for at least the same reasons as for Claims 22, 32 and 38.

Claims 11, 13-21, 23, and 36-37 stand rejected under 35 U.S.C. 103(a) as being unpatentable over the combination of Szeliski and Seago, and in further view of Blank (US Patent Number 5,469,536).

The rejections of Claims 11, 13-21, 23, and 36-37 for obviousness rely on Szeliski and Seago for teaching the limitations cited above for Claim 22 and 32, namely: limitation (b) of Claim 22, where the object occupies a field of view of more than 180 degrees in the panorama as required by limitation (a) of Claim 22. Therefore, a prima facie case of obviousness is lacking for each of these claims because, as shown above, Szeliski and Seago do not teach, disclose or suggest these limitations of the claims. Claims 11, 13-21, 23, and 36-37 are therefore deemed patentable over the cited references.

Claims 1-3, 5-6, 8-10 and 39 stand rejected under 35 U.S.C. 103(a) as being unpatentable over Szeliski in view of Luken (US Patent Number 5,923,334), and in further view of Seago.

The rejections of Claims 1-3, 5-6, 8-10 and 39 for obviousness rely on Szeliski and Seago for teaching the limitations cited above in rejecting Claim 22 and 32, namely: limitation (b) of Claim 22, where the object occupies a field of view of more than 180 degrees in the panorama as required by limitation (a) of Claim 22. Therefore, a prima facie case of obviousness is lacking for each of these claims because, as shown above, Szeliski and Seago do not teach,

disclose or suggest these limitations of the claims. Claims 1-3, 5-6, 8-10 and 39 are therefore deemed patentable over the cited references.

Claim 7 stands rejected under 35 U.S.C. 103(a) as being unpatentable over the combination of Szeliski, Luken, and Seago, and in further view of Blank.

The rejection of Claim 7 for obviousness relies on Szeliski and Seago for teaching the limitations cited above in rejecting Claim 22 and 32, namely: limitation (b) of Claim 22, where the object occupies a field of view of more than 180 degrees in the panorama as required by limitation (a) of Claim 22. Therefore, a prima facie case of obviousness is lacking for Claim 7 because, as shown above, Szeliski and Seago do not teach, disclose or suggest these limitations of the claims. Claim 7 is therefore deemed patentable over the cited references.

Applicant requests reconsideration of all pending claims and a notice of allowance. The Examiner is requested to telephone the undersigned if any matters remain outstanding so that they may be resolved expeditiously. The Commissioner is hereby authorized to charge any deficiency in the fees filed, asserted to be filed or which should have been filed herewith to our Deposit Account No. 19-4972.

Respectfully submitted,

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Appendix 1

Seago '900's Method's Deficiency for Modeling an Object from Multiple Incomplete 2D Perspective Images.

Seago '900 does not teach the steps for creating an accurate 3D object model from multiple 2D perspective images, unless each 2D image contains the complete object.

Seago '900 addresses generating a single, 3D object from multiple two-dimensional images of a single object <u>only</u> at the following passages: col. 7, line 29 through col. 8, line 42; fig. 6A and 6B; and col. 11, lines 45-47. Thus, if Seago' 900 teaches creating a 3D model from multiple incomplete 2D images, the teaching must be in those passages. Analysis of these passages shows that these passages do not provide such a teaching.

Seago's explanation begins by stating:

> "FIG. 6A illustrates the process by which the image converting system 20 shown in FIG. 1 generates a single three-dimensional object from two or more three-dimensional objects created from two-dimensional images of a single object, as shown in FIGS. 2-4 (sic)." (Col. 7, lines 29-33).

Seago then refers to blocks 120 and 122 of fig 6A to require that relative orientation information between each 2D perspective view be determined:

> "At block 120, a sufficient set of features or significant features are identified on each two-dimensional object in the multiple views. A sufficient set of features may include any set of matching or conjugate vertices, vanishing lines or planes between the multiple images. The set is sufficient when the conjugate matches between the images provides enough information for determining relative orientation information between each view.
>
> Relative orientation for each view is determined at block 122. The relative orientation of a view is how the vertices, vanishing lines or planes it sees correspond to those of the other views. For example, if

> two views of the same object differ by 180.degree., the left vanishing lines and planes in one view are the right vanishing lines and planes in other view.“ (Col. 7, lines 33-47).

When each 2D image does not contain a complete object – as illustrated in figs. 8-12 above – a complete set of matching points do not exist because of the ambiguities introduced by the incomplete image. Seago does not address a remedy for this situation. The example of views differing by 180 degrees and that “left vanishing lines and planes in one view are right vanishing lines and planes in the other” merely describes one example of disparate views of the same object, but do not address the fundamental problem of insufficient conjugate points between incomplete objects in the views.

Seago then goes on to describe creating a single 3D object model from 3D models created from each of the multiple 2D images at block 124 of fig. 6A:

> “At block 124, the single three-dimensional object is created in world coordinate space based on the three-dimensional coordinate spaces (SWCS) for each image, and the objects in each two-dimensional image and the determined relative orientations. The origin of the world coordinate space is set at a default position and the orientation is set to a default orientation. If components of the created three-dimensional object are inverted or out of place because of ambiguous or improper relative orientation determination, the user can manually correct the created object by using the user interface.
>
> The three-dimensional object generation is performed according to the process illustrated in FIG. 6B and described in more detail below...” (Col. 7, lines 50-62).

Seago then describes the process of generating a single 3D object from multiple 3D objects. The basic process of modeling each object is as shown in figs 2-4 and applied as follows:

"FIG. 6B illustrates the three-dimensional object generation process from block 124 of FIG. 6A.

First, at block 128, planes referenced to the world coordinate space are set at a default position, each image's viewpoint is set at a default position in world coordinate space and each image's viewpoint is set to a default focal length and orientation.

Next, at block 130, the intersection points of the set planes which correspond to vertices in the created three-dimensional object are projected onto each image's image plane using each image's set viewpoint focal length.

At block 132, the projected vertices' two-dimensional values on the image planes are determined.

Then, at block 134, the image plane location of each designated vertex of the selected object is compared to its corresponding determined projected vertex. An error function is determined based on the comparisons. See block 136

Next, at block 138, an iterative non-linear numerical optimization algorithm is executed according to the determined error function. More specifically, at decision block 140, the non-linear optimization algorithm determines if the determined error function is at an acceptably low level. An acceptable error function level exists when the difference between the projected vertices and the selected object's vertices is below a minimal value.

If the determined error function is at an acceptably low level, the process continues as shown in FIG. 6A. However, if the non-linear optimization algorithm determines that the determined error function is not at an acceptably low level, the planes' positions and each image's position in world coordinate space, and each image's viewpoint focal length and orientation are adjusted based on the determined error function. See block 142. The planes are adjusted by moving each plane along the world coordinate space axis that is parallel to the plane's normal vector. The viewpoints' positions are adjusted by moving each viewpoint within the world coordinate system. The viewpoints' orientations are adjusted by orienting each viewpoint with respect to the world coordinate system. Focal length of each images' viewpoint is adjusted along the normal from the center of its respective image. These adjustments change the position of all projected vertices, thereby changing the ensuing comparison. After adjustment has taken place, the steps performed in

> blocks 130-136 are repeated until an acceptable three-dimensional model is found. Three-dimensional object generation is illustrated by an example shown in FIG. 12 and described below." (Col. 7, lines 66 to col. 8, line 42).

Steps 128 – 140 of fig. 6B address adjusting positions of planes and viewpoints in the world coordinate system and the viewpoints parameters so that the projected vertices on the 2D images and the object vertices are acceptably close to each other. These steps, however, say nothing about creating a single complete 3D object model from two or more incomplete 3D models. For example, no mention is made of filling the gaps in any single 3D model that arise from the incomplete 2D images.

Seago finishes the discussion of creating a single 3D object model as follows:

> As will be readily appreciated by those of ordinary skill in the art of graphics processing and manipulation, various graphical tools and computer system components may be used to perform many of the user interactions described above. <u>While FIGS. 7-13 show an implementation of the invention using only a single input image, the system can also use two or more input images. In this case the steps illustrated in FIGS. 6A and 6B and described above are applied to all images</u>. (Col. 7, lines 29-33).

Clearly, Seago '900 provides no teaching that would enable one of ordinary skill in the art to create a single 3D model from two or more incomplete 3D models created from two or more input 2D perspective images that do not contain the complete object. If the Examiner disagrees, Applicant respectfully requests that the Examiner state for the record specifically where such teachings are found in Seago '900.